HUGHES
AIRCRAFT COMPANY

# 8000H INSTRUMENTATION AMPLIFIER
# OPERATION AND MAINTENANCE MANUAL

## VOLUME I

## OPERATION AND OPERATOR MAINTENANCE MANUAL

INSTRUMENTATION SERIES
TRAVELING WAVE TUBE AMPLIFIERS

JULY 1985

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# 1.0 GENERAL DESCRIPTION

## 1.1 INTRODUCTION

### 1.1.1 Purpose of the Equipment

The 8000H Series Instrumentation Amplifiers are broadband laboratory instruments designed for general purpose microwave applications. Each amplifier consists of a traveling wave tube (TWT) and an efficient solid state electronic power conditioner (EPC). RF power output of the basic 8000H models are 1, 10, or 20 watts. Modifications are available for special applications as options to the standard models.

### 1.1.2 Scope of This Manual

This manual describes the standard 8000H Series Instrumentation Amplifier and the options available. The manual is divided into two volumes.

Volume I is concerned with initial installation and operation of the amplifier. The amplifier is described in terms of application and performance capabilities. Operation instructions, functional purposes of major circuits of interest to the operator, and preventive maintenance and repair are set forth. Unpacking and packing for shipment or storage, initial installation and warranty information complete Volume I.

Volume II is concerned with depot maintenance and includes sections on theory of operation, field adjustments, performance testing, trouble-shooting, subassembly removal, and repair. Parts lists, assembly drawings, and schematics are also included.

### 1.1.3 Use of This Manual

This manual is limited to standard instrumentation amplifiers and the most common options. Amplifiers ordered with special options will have addenda pages included with the basic manual, containing material applicable for their special operation and maintenance.

## 1.2 SPECIFICATIONS AND STANDARD AMPLIFIER OPTIONS

Table 1-1 gives the characteristics of standard instrumentation amplifiers. Table 1-2 sets forth the modifications available as options of the standard amplifier.

## 1.3 PHYSICAL DESCRIPTION

Each amplifier consists of a PPM-focused metal-ceramic traveling wave tube, a highly regulated, solid state power supply, and integral air cooling system assembled within a compact case. The amplifier may be used as a bench-top instrument or mounted in a standard 19-inch rack. Figure 1-1 (Dwg. No. CDB734601) shows the outline and mounting dimensions of the standard amplifier with identification of front and rear panel features. The amplifier is modularly assembled to facilitate maintenance and replacement. Figure 1-2 (Dwg. No. WDB732425) is a drawing from the top showing the layout of the major components. Table 1-3 lists the operating modules of the amplifier.

## TABLE 1-1

## SPECIFICATIONS

| TWTA Model Number | TWTA Rated Output (Watts) | Frequency (GHz) | TWT Model Number | RF Connectors (In/Out) |
|---|---|---|---|---|
| 8001H11F-000 | 1 | 18.0-26.5 | 911H | Ug-596 |
| 8001H12F-000 | 1 | 26.5-40.0 | 912H | UG-600 |
| 8010H09F-000 | 10 | 1.0-2.0 | 417HD | Type "N" |
| 8010H01F-000 | 10 | 2.0-4.0 | 564H | Type "N" |
| 8010H13F-000 | 10 | 3.0-8.0 | 646H | Type "N" |
| 8010H16F-000 | 10[1] | 3.9-11.7 | 664H | Type "N" |
| 8010H02F-000 | 10 | 4.0-8.0 | 648HD | Type "N" |
| 8010H06F-000 | 10[1] | 4.0-10.5 | 648HDS | Type "N" |
| 8010H07F-000 | 10 | 6.5-13.5 | 771HDS | Type "N" |
| 8010H03F-000 | 10 | 8.0-12.4 | 771HD | Type "N" |
| 8010H04F-000 | 10 | 12.4-18.0 | 848HD | SMA |
| 8010H15F-000 | 10 | 8.0-18.0 | 846H | SMA |
| 8020H09F-000 | 20 | 1.0-2.0 | 418H | Type "N" |
| 8020H10F-000 | 20 | 1.4-2.4 | 419H | Type "N" |
| 8020H01F-000 | 20 | 2.0-4.0 | 568H | Type "N" |
| 8020H02F-000 | 20 | 4.0-8.0 | 640H | Type "N" |
| 8020H03F-000 | 20 | 8.0-12.4 | 783H | Type "N" |
| 8020H04F-000 | 20 | 12.4-18.0 | 856H | SMA/UG-419 |
| 8020H15F-000 | 20 | 8.0-18.0 | 889H | SMA |

**Electrical**

Gain at Rated Power Output ..... 30 dB minimum
Duty ..... CW
Input Voltage ..... 95-135 VAC
Input Frequency ..... 47-63 Hz
Power Consumption.....8001H ..... 115 Watts [2]
.....8010H ..... 250 Watts
.....8020H ..... 280 Watts
Noise Figure ..... 35 dB maximum
Spurious Modulation (at saturation) ..... -50 dBc
Coax Input/Output Impedance ..... 50Ω nominal
Gain Stability ..... 0.25 dB/24 hours[3]
Load VSWR (no damage)..... 2.5:1 maximum[4]

**Mechanical**

Size/Configuration ..... (See Figure 1-1)
Weight ..... 20 pounds (9.1 kg)

**Environmental**

Operating Temperature ..... 0 to 50°C ambient

*Specifications subject to change without notice.

1. Power and gain slightly lower at band edges.
2. This indicates maximum power consumption of any model in that series. For information on a specific model consult factory.
3. At constant drive and temperature after warmup period.
4. Option J is required for higher load VSWR applications.

TABLE 1-2

STANDARD OPTIONS

**Option A - 220/240 V Input Voltage**
Provisions for 198 - 264 VAC at 50/60 Hz Operation.

**Option D - Unattended Operation**
In the event of helix overcurrent, the TWTA will power down, removing all voltages from the TWT. A manual reset of the prime power switch is required to resume normal operation.

**Option E - Rackmounting**
Rack mount ears for standard EIA 19-inch cabinets.

**Option F - Local/Remote**
Provides remote control of the amplifier's ON/OFF prime power switch and the OPERATE/STANDBY switch. Fault status and an analog voltage, proportional to the amplifier's helix current, are also made available. This option requires user to supply 15 VDC at 300 mA for remotely operating the unit. In the local control mode, internally supplied power is used.

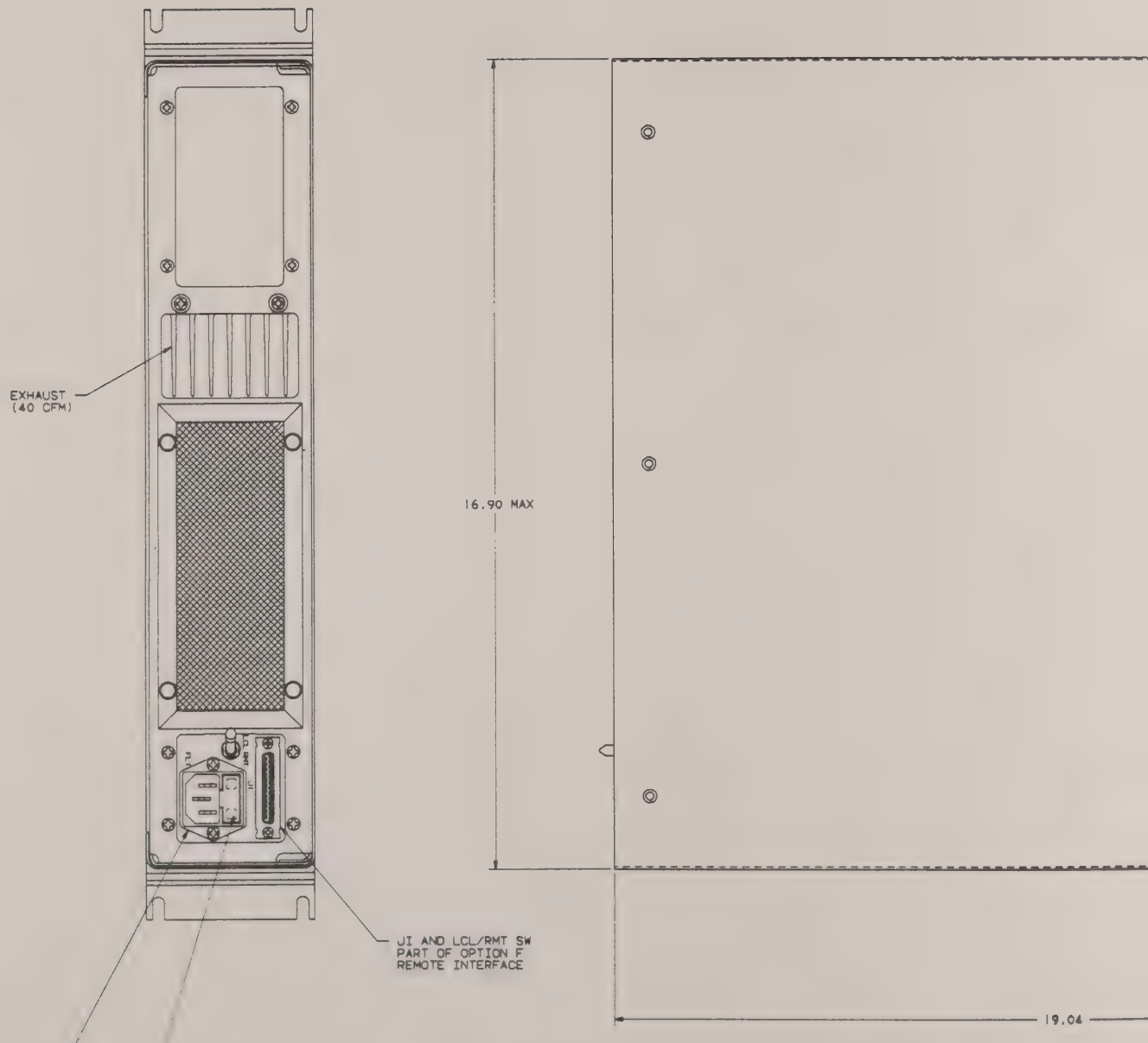
**Option G - 400 Hz**
Provisions for 380 to 420 Hz operation.

**Option H - TTL Remote Interface**
This option replaces the standard Option F with TTL interface logic. The user may supply either 28 VDC or 15 VDC externally to the remote control circuitry. Maximum current is 400 mA for either voltage.

**Option J - Output Isolator**
Protects the traveling wave tube from high external load VSWR conditions.

**Option K - High Gain**
Adds a solid state amplifier at the input to the traveling wave tube for higher gain when only minimal drive power is available. Consult the factory for specific requirement.

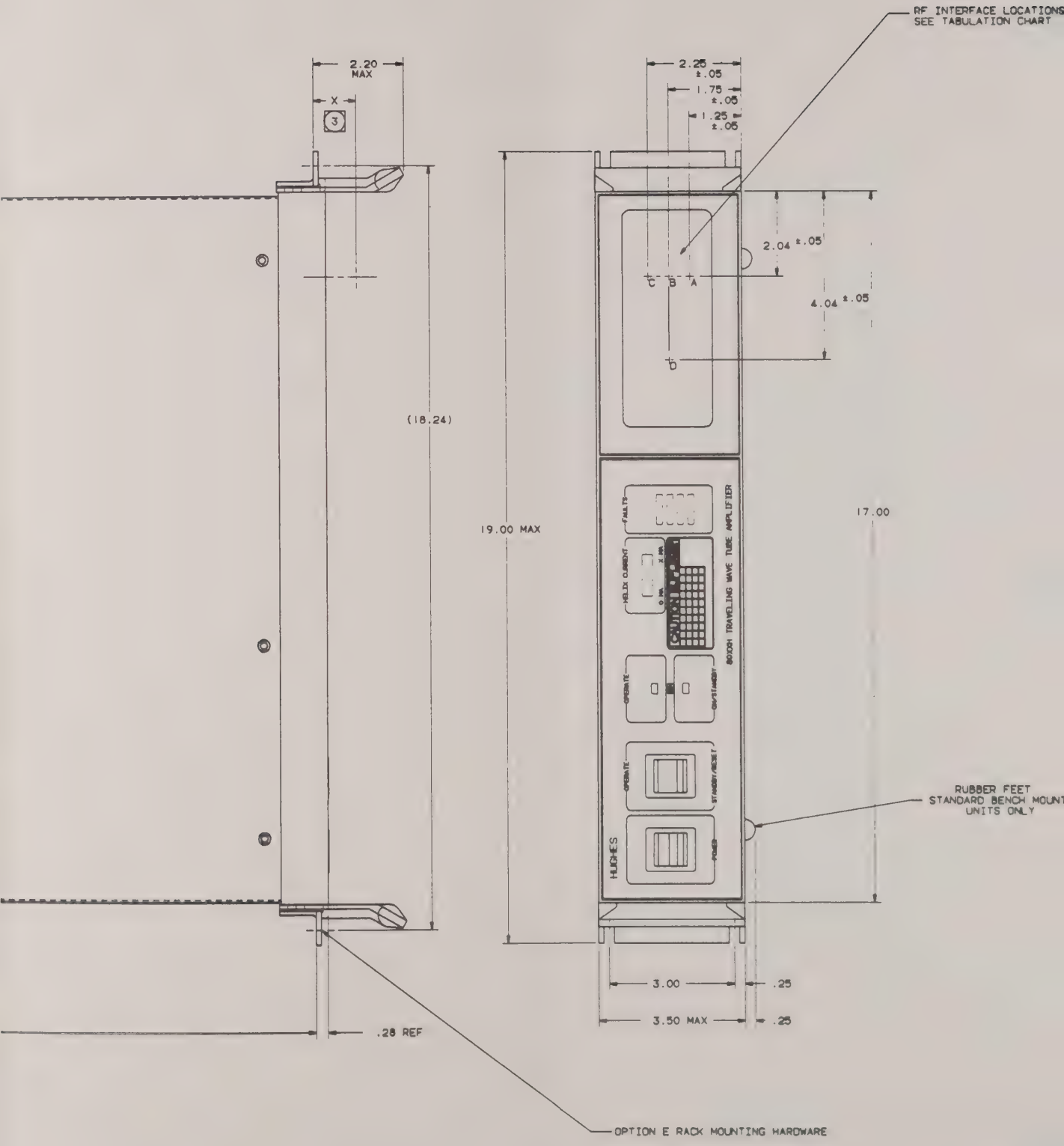
**Option N - Variable Attenuator**
A variable front panel RF attenuator provides gain control over more than a 20 dB range.




3 DIM X FOR:
WAVEGUIDE = .450±.05
TYPE N CONN = 1.025±.05
SMA CONN = .625±.05

2. COAXIAL CONNECTORS ARE TYPE N OR SMA (FM).
1. UG419/U FLANGES ARE MODIFIED TO PROVIDE MOUNTING HOLES, THREADED #6-32 UNC-2B.

NOTES: UNLESS OTHERWISE SPECIFIED




CD8734601

FIGURE 1-1a TWTA, 8000H

REVISIONS

| EFF | AUTHORITY | ZONE | LTR | DESCRIPTION | DATE | APPROVED |
|---|---|---|---|---|---|---|
| | | | A | RF INTERFACE CHART.<br>UNIT DESIG. 8010H03F WAS H010H03F<br>UNIT DESIG. 8010H04F OUTPUT TYPE WAS WR62, UG419<br>UNIT DESIG. 8020H04F OUTPUT TYPE WAS SMA | 85-07-31 | R.PERRY<br>B.BEHLER |
| | ENG | | B | RF INTERFACE CHART<br>UNIT DESIG. 8010H08F, OUTPUT TYPE WAS WR62, UG419<br>J1 REMOTE CONTROL INTERFACE CHART<br>ANALOG WAS TELEMETRY, PIN NO.10 NOMENCLATURE WAS Iv, PIN NO.11 NOMENCLATURE WAS RF (RCU OPTION) | 85-08-26 | R.PERRY<br>B.BEHLER |

RF INTERFACE

| UNIT DESIG. | INPUT | | OUTPUT | |
|---|---|---|---|---|
| | LOCATION | TYPE | LOCATION | TYPE |
| 8001H11F | C | WR42, UG596 | A | WR42, UG596 |
| 8001H12F | C | WR28, UG600 | A | WR28, UG600 |
| 8010H01F | D | N | B | N |
| 8010H02F | D | N | B | N |
| 8010H03F | D | N | B | N |
| 8010H04F | D | SMA | B | SMA |
| 8010H06F | D | N | B | N |
| 8010H07F | D | N | B | N |
| 8010H08F | D | SMA | B | SMA |
| 8010H09F | D | N | B | N |
| 8010H13F | D | N | B | N |
| 8010H14F | D | N | B | N |
| 8010H15F | D | SMA | B | SMA |
| 8010H16F | D | N | B | N |
| 8010H17F | D | N | B | N |
| 8020H01F | D | N | B | N |
| 8020H02F | D | N | B | N |
| 8020H03F | D | N | B | N |
| 8020H04F | D | SMA | B | WR62, UG419 |
| 8020H05F | D | N | B | N |
| 8020H09F | D | N | B | N |
| 8020H10F | D | N | B | N |

J1 REMOTE CONTROL INTERFACE (OPTION F)
CANNON DBMA-25S OR EQUIVALENT

| PIN # | NOMENCLATURE | CHARACTERISTICS |
|---|---|---|
| | COMMANDS | |
| 1 | POWER ON | FORM "A" CONTACT TO GROUND 150 MA MAX |
| 2 | OPERATE | FORM "A" CONTACT TO GROUND 65 MA MAX |
| 13 | COMMAND ENABLE +15VDC | +15VDC ±.5V @ 215 MA MAX USER SUPPLIED |
| | STATUS | |
| 3 | POWER ON | OPEN COLLECTOR DARLINGTON OUTPUT.(EMITTER GROUNDED) +50V MAX STANDOFF |
| 5 | OPERATE | |
| 22 | REMOTE INDICATOR | FORM "A" CONTACT TO GROUND 100 MA MAX |
| | FAULTS | |
| 6 | LINE UNDER VOLTAGE | OPEN COLLECTOR DARLINGTON OUTPUT.(EMITTER GROUNDED) +50V MAX STANDOFF |
| 7 | INTERLOCK | |
| 8 | THERMAL | |
| 9 | HELIX CURRENT | |
| 4 | SUMMARY FAULT | |
| 14 | SUMMARY FAULT (VPC/RCU SUBSYSTEM USE) | LOW=FAULT(<1V), Z OUT=1KΩ, HIGH=NORM(APX 14V) |
| 15 | LOW RF (RCU OPTION) | HIGH=FAULT(APX 14V), LOW=NORM(<1V) Z OUT=1KΩ |
| | ANALOG | |
| 10 | HELIX CURRENT | 0 TO 5V FULL SCALE, Z OUT=1KΩ |
| 11 | RF PWR (RCU OPTION) | SAME |
| 17 | GROUND | |

INSTALLATION CONTROL DWG

| QTY REQD | UNIT OF MEASURE | FSCM NO | PART NO OR IDENTIFYING NO | NOMENCLATURE OR DESCRIPTION | ITEM OR FIND NO |
|---|---|---|---|---|---|
| | | | PARTS LIST | | MWSS |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND PER ANSI Y14.5
.010 .02
± ±
ANGLES ±0°30' FINISH 63√

MATERIAL

CONTRACT:

DR M.GRUDIER 85-03-25
CHK R.PERRY 85-07-16
APPD B.BEHLER 85-07-15

HUGHES AIRCRAFT COMPANY
ELECTRON DYNAMICS DIVISION
TORRANCE, CALIF. 90509

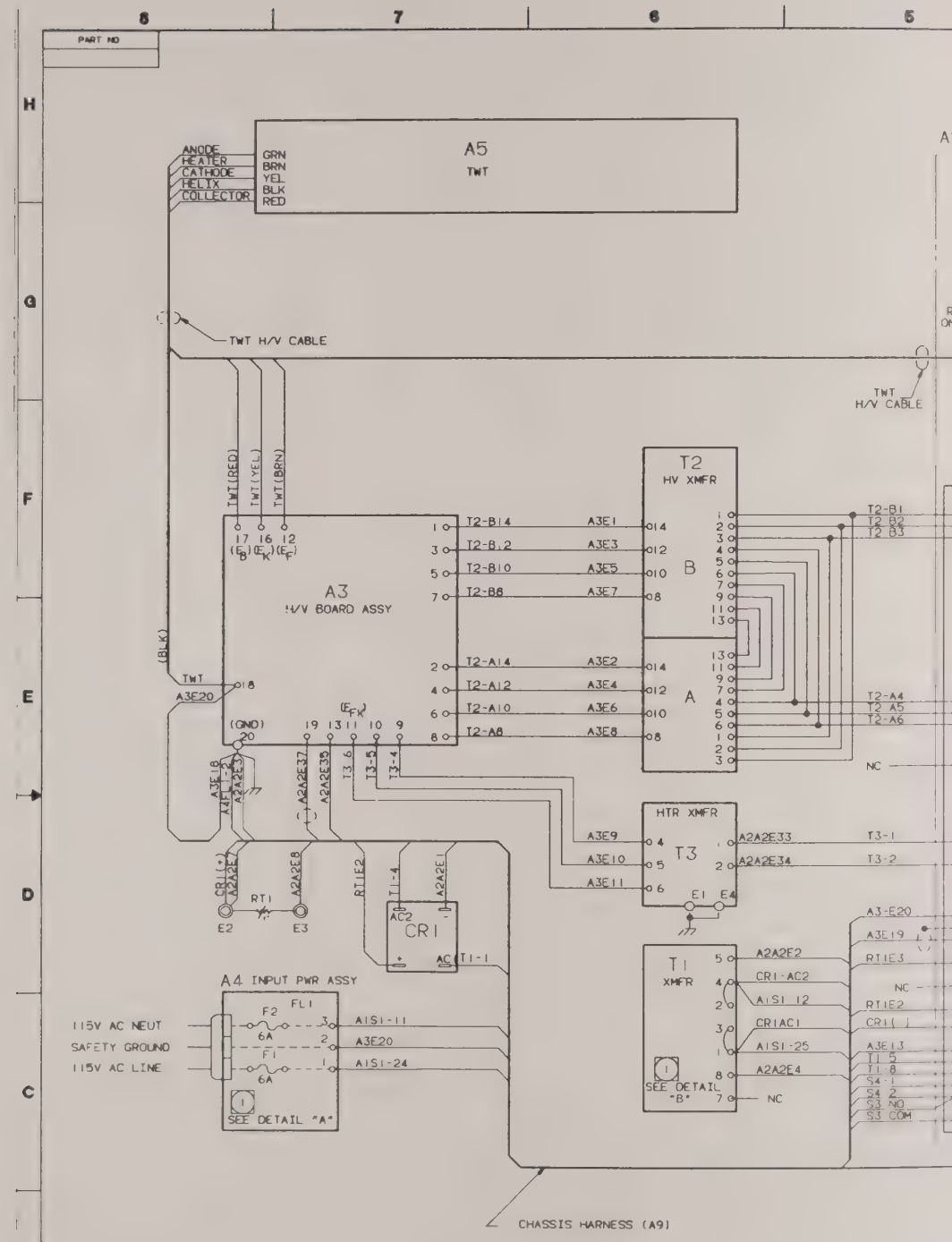
TWTA, 8000H

| SIZE | FSCM NO | DWG NO | REV |
|---|---|---|---|
| J | 73293 | CDB734601 | B |

SCALE 1/1 CADAM SHEET

| NEXT ASSY | USED ON |
|---|---|
| APPLICATION | |
| | 8020H |
| | 8010H |
| | 8001H |

FIGURE 1-1b




3 FOR UNITS WITH OPTION"K" (HIGH PWR)SEE SHEET 3,DETAIL E.

2 F2 ON OPTION "A" 220/240V UNITS ONLY.

1 CONFIGURATIONS SHOWN ARE FOR 8XXXH AND 9XXXHA MODELS ONLY:
SHEET 1- STANDARD UNIT WITH NO OPTIONS
SHEET 2- OPTION "F" REMOTE INTERFACE UNITS
SHEET 3- OPTION "A" 220/240V OPERATION.
OPTION "K" HIGH GAIN
- 9075HA VARIATIONS

NOTES UNLESS OTHERWISE SPECIFIED

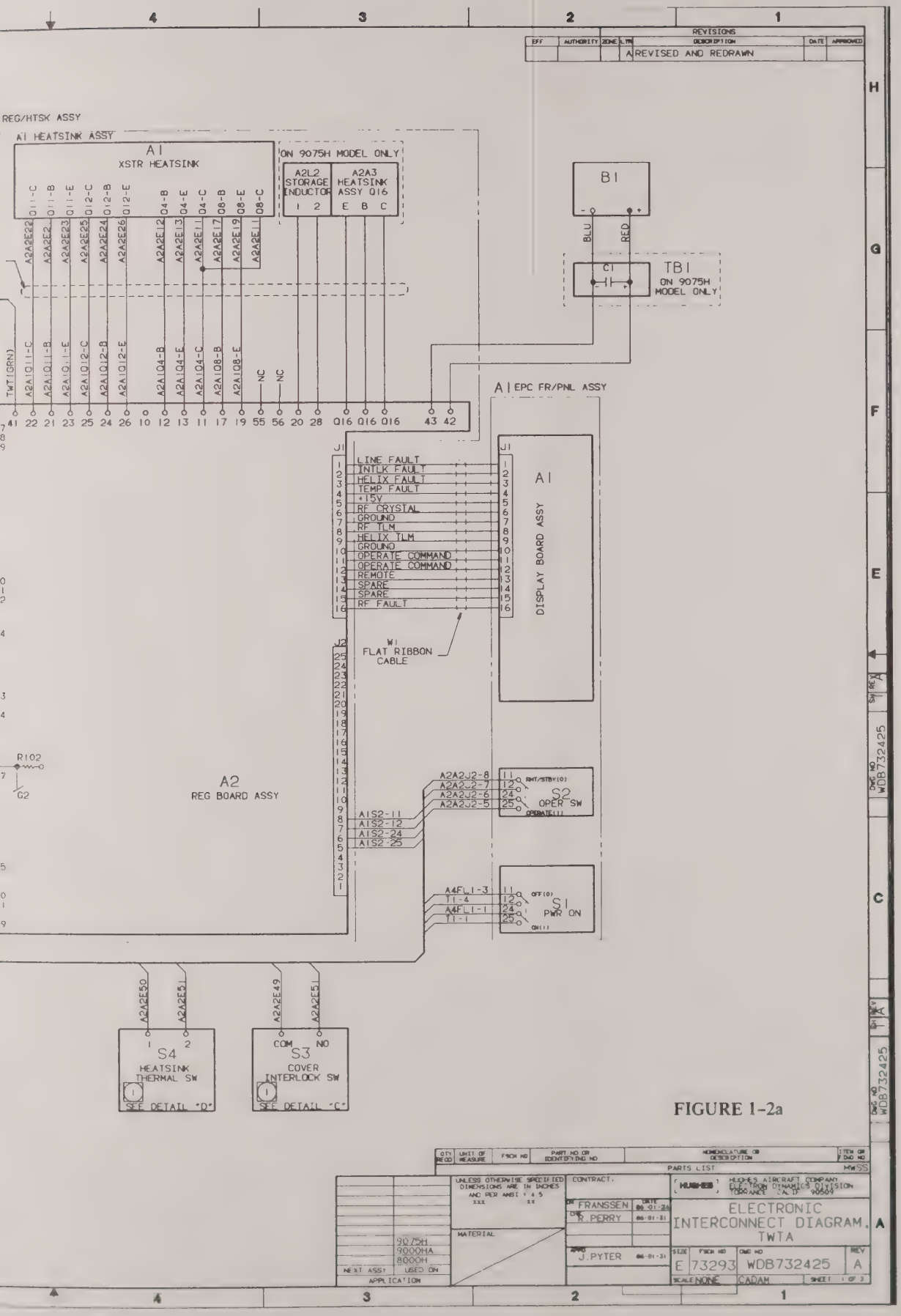
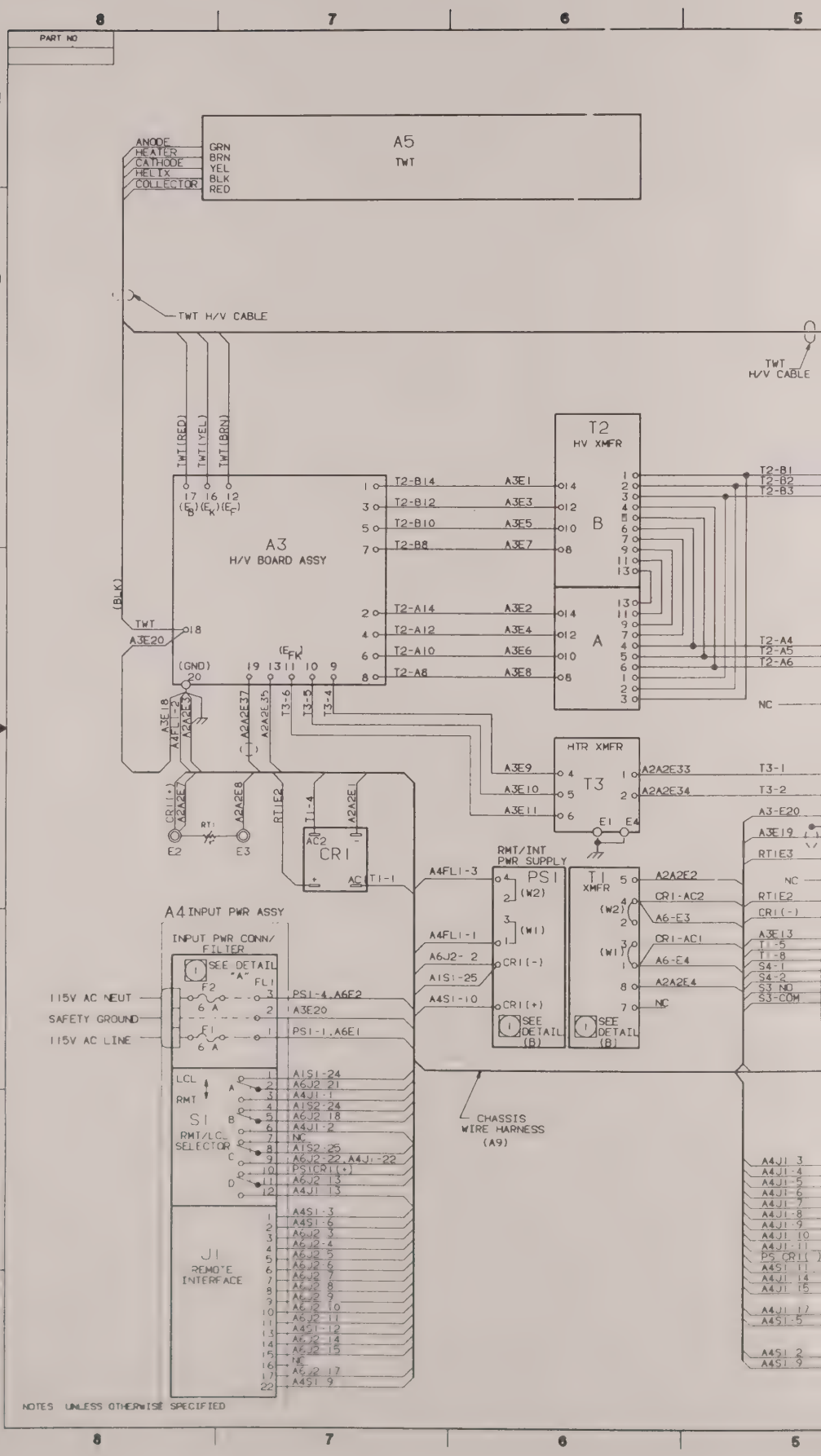

REVISIONS
A REVISED AND REDRAWN
REG/HTSK ASSY
A1 HEATSINK ASSY
A1
XSTR HEATSINK
ON 9075H MODEL ONLY
A2L2 STORAGE INDUCTOR
A2A3 HEATSINK ASSY Q16
B1
BLU
RED
C1
TB1
ON 9075H MODEL ONLY
A1 EPC FR/PNL ASSY
LINE FAULT
INTLK FAULT
HELIX FAULT
TEMP FAULT
+15V
RF CRYSTAL
GROUND
RF TLM
HELIX TLM
GROUND
OPERATE COMMAND
OPERATE COMMAND
REMOTE
SPARE
SPARE
RF FAULT
A1
DISPLAY BOARD ASSY
W1
FLAT RIBBON CABLE
A2
REG BOARD ASSY
R102
G2
S2
OPER SW
S1
PWR ON
S4
HEATSINK THERMAL SW
SEE DETAIL "D"
S3
COVER INTERLOCK SW
SEE DETAIL "C"
PARTS LIST
ELECTRONIC INTERCONNECT DIAGRAM, TWTA
HUGHES AIRCRAFT COMPANY
ELECTRON DYNAMICS DIVISION
TORRANCE, CA. 90509
9075H
9000HA
8000H
J.PYTER
E 73293
WDB732425
A

FIGURE 1-2a


PART NO
A5
TWT
ANODE
HEATER
CATHODE
HELIX
COLLECTOR
GRN
BRN
YEL
BLK
RED
TWT H/V CABLE
TWT H/V CABLE
TWT(RED)
TWT(YEL)
TWT(BRN)
A3
H/V BOARD ASSY
T2
HV XMFR
T2-B14
T2-B12
T2-B10
T2-B8
T2-A14
T2-A12
T2-A10
T2-A8
A3E1
A3E3
A3E5
A3E7
A3E2
A3E4
A3E6
A3E8
T2-B1
T2-B2
T2-B3
T2-A4
T2-A5
T2-A6
NC
TWT
A3E20
(GND)
HTR XMFR
T3
A3E9
A3E10
A3E11
A2A2E33
A2A2E34
T3-1
T3-2
CR1
RT1
E1
E2
E3
E4
A4 INPUT PWR ASSY
INPUT PWR CONN/ FILTER
SEE DETAIL "A"
F2
F1
6 A
115V AC NEUT
SAFETY GROUND
115V AC LINE
PS1-4,A6E2
A3E20
PS1-1,A6E1
RMT/INT PWR SUPPLY
PS1
T1 XMFR
A4FL1-3
A4FL1-1
A6J2-2
A1S1-25
A4S1-10
CR1(-)
CR1(+)
A2A2E2
CR1-AC2
A6-E3
CR1-AC1
A6-E4
A2A2E4
NC
SEE DETAIL (B)
LCL
RMT
S1
RMT/LCL SELECTOR
A1S1-24
A6J2 21
A4J1-1
A1S2-24
A6J2 18
A4J1-2
A1S2-25
A6J2-22,A4J1-22
PS1(CR1(+))
A6J2 13
A4J1 13
J1
REMOTE INTERFACE
A4S1-3
A4S1-6
A6J2 3
A6J2-4
A6J2 5
A6J2 6
A6J2 7
A6J2 8
A6J2 9
A6J2 10
A6J2 11
A4S1-12
A6J2 14
A6J2 15
A6J2 17
A4S1 9
CHASSIS WIRE HARNESS (A9)
A3-E20
A3E19
RT1E3
RT1E2
CR1(-)
A3E13
T1-5
T1-8
S4-1
S4-2
S3 NO
S3-COM
A4J1 3
A4J1-4
A4J1-5
A4J1-6
A4J1-7
A4J1-8
A4J1-9
A4J1 10
A4J1-11
PS CR1( )
A4S1 11
A4J1 14
A4J1 15
A4J1 17
A4S1-5
A4S1 2
A4S1 9
NOTES UNLESS OTHERWISE SPECIFIED

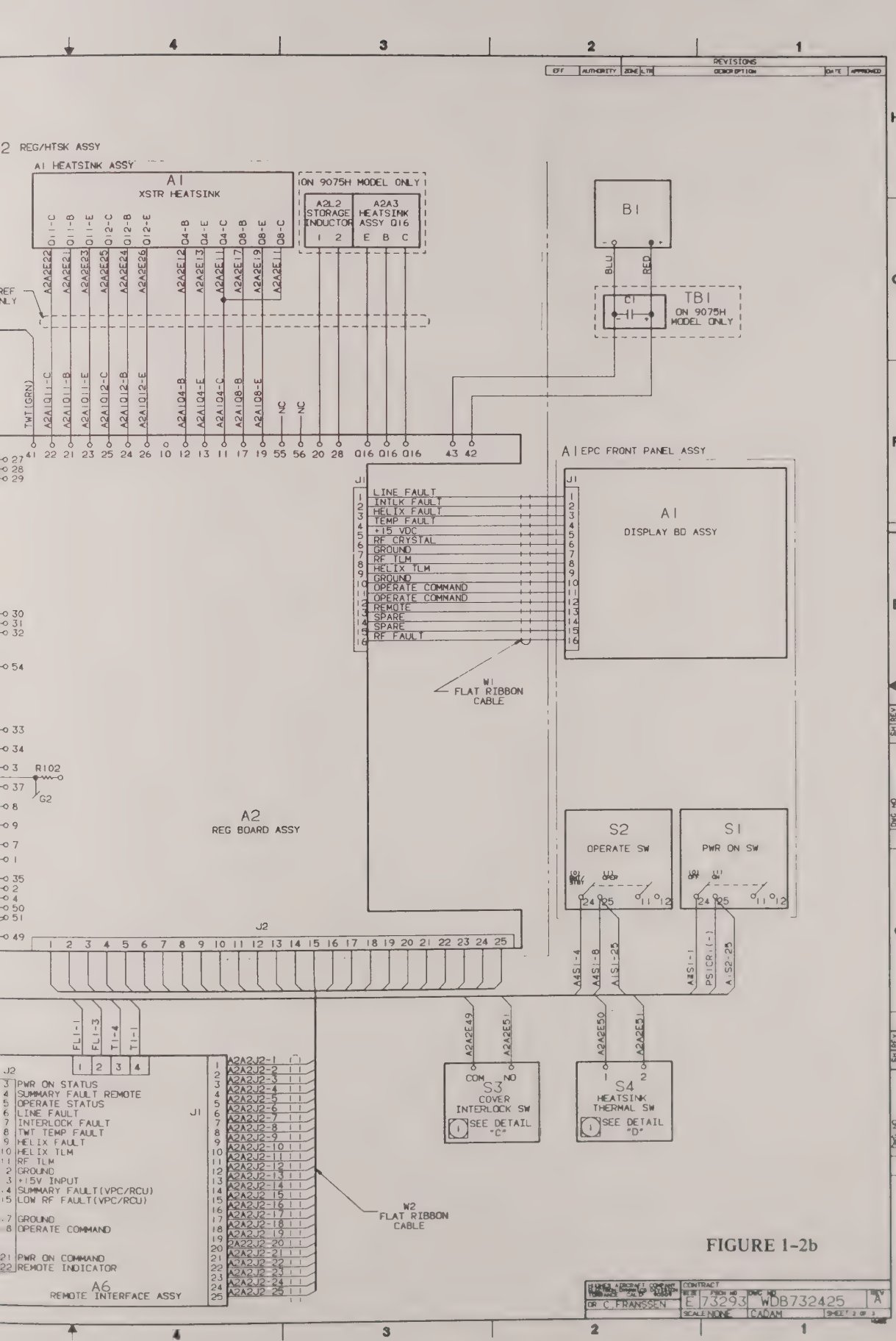
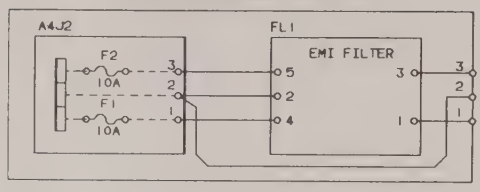

REVISIONS
A2 REG/HTSK ASSY
A1 HEATSINK ASSY
A1
XSTR HEATSINK
ON 9075H MODEL ONLY
A2L2
STORAGE
INDUCTOR
A2A3
HEATSINK
ASSY Q16
B1
BLU
RED
C1
TB1
ON 9075H
MODEL ONLY
A1 EPC FRONT PANEL ASSY
J1
LINE FAULT
INTLK FAULT
HELIX FAULT
TEMP FAULT
+15 VDC
RF CRYSTAL
GROUND
RF TLM
HELIX TLM
GROUND
OPERATE COMMAND
OPERATE COMMAND
REMOTE
SPARE
SPARE
RF FAULT
A1
DISPLAY BD ASSY
W1
FLAT RIBBON
CABLE
R102
G2
A2
REG BOARD ASSY
S2
OPERATE SW
S1
PWR ON SW
J2
S3
COVER
INTERLOCK SW
SEE DETAIL
"C"
S4
HEATSINK
THERMAL SW
SEE DETAIL
"D"
PWR ON STATUS
SUMMARY FAULT REMOTE
OPERATE STATUS
LINE FAULT
INTERLOCK FAULT
TWT TEMP FAULT
HELIX FAULT
HELIX TLM
RF TLM
GROUND
+15V INPUT
SUMMARY FAULT(VPC/RCU)
LOW RF FAULT(VPC/RCU)
GROUND
OPERATE COMMAND
PWR ON COMMAND
REMOTE INDICATOR
A6
REMOTE INTERFACE ASSY
W2
FLAT RIBBON
CABLE
DR C. FRANSSEN
CONTRACT
E 73293
WDB732425
SCALE NONE
CADAM

FIGURE 1-2b

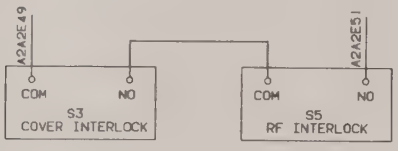
PART NO

9075H ONLY
INPUT POWER CONNECTOR/FILTER



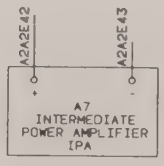

DETAIL A

SAFETY INTERLOCK ON UNITS WITH TYPE "N"
RF OUTPUT CONNECTOR SOLD PRIOR TO 1 FEB 1986




DETAIL C

OPTION "K" HIGH GAIN OPERATION




DETAIL E

NOTES UNLESS OTHERWISE SPECIFIED

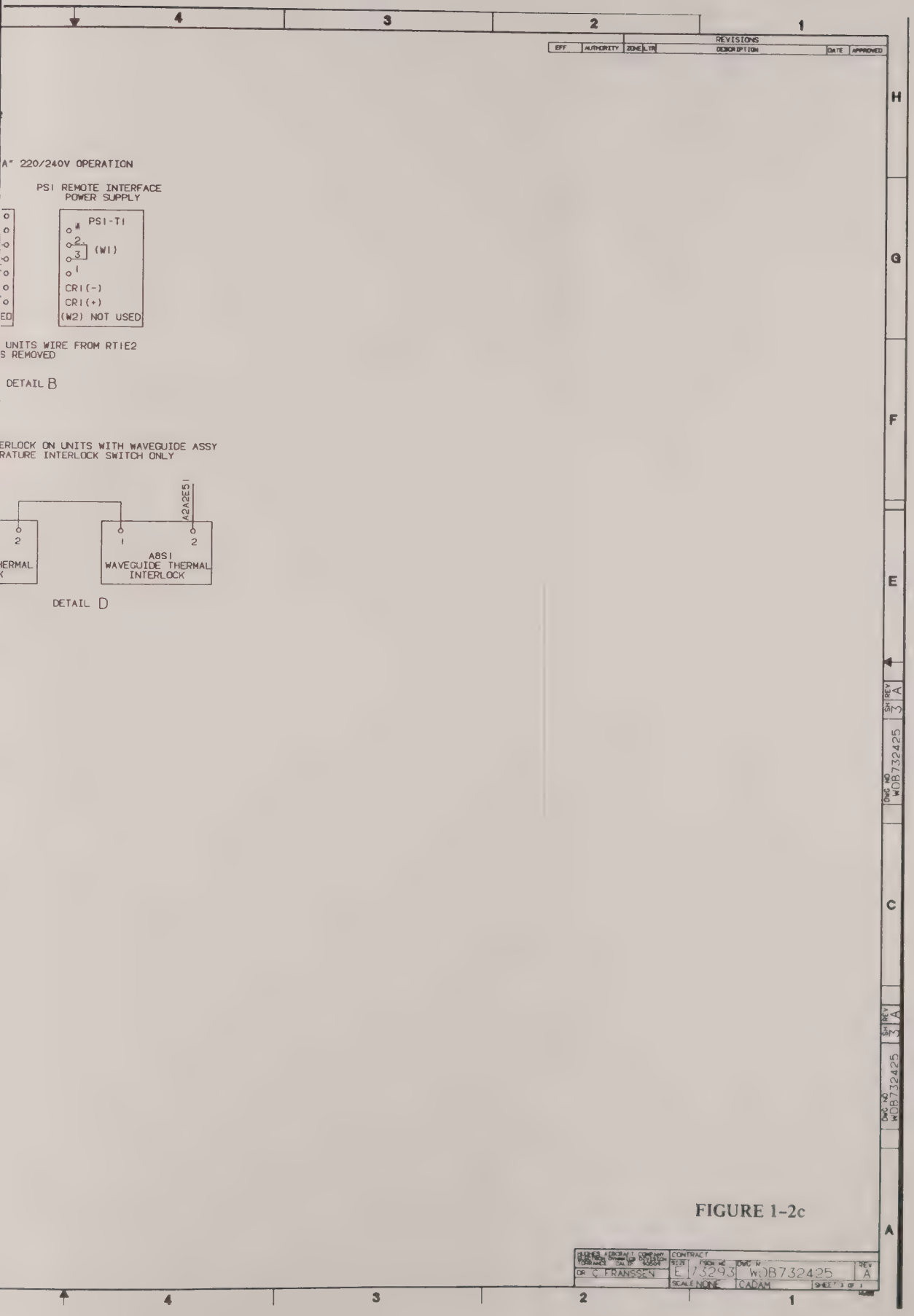

REVISIONS
EFF
AUTHORITY
ZONE
LTR
DESCRIPTION
DATE
APPROVED
A" 220/240V OPERATION
PSI REMOTE INTERFACE
POWER SUPPLY
PSI-T1
(W1)
CR1(-)
CR1(+)
(W2) NOT USED
UNITS WIRE FROM RTIE2
S REMOVED
DETAIL B
ERLOCK ON UNITS WITH WAVEGUIDE ASSY
RATURE INTERLOCK SWITCH ONLY
A2A2E51
A8S1
WAVEGUIDE THERMAL
INTERLOCK
DETAIL D
DR C FRANSSEN
CONTRACT
E 73293
DWG NO W08732425
REV A
SCALE NONE
CADAM
SHEET 3 OF 3
DWG NO W08732425
REV A
SH 3
DWG NO W08732425
REV A
SH 3

FIGURE 1-2c

## TABLE 1-3

## BASIC MODULES, INSTRUMENTATION AMPLIFIER

| | |
|---|---|
| Display Board | B704155-001 |
| Regulator Board[1] | B704194-001 |
| High Voltage Board[1] | B704156-001 |
| Remote Interface Board (Option F) | B724485-001 |

[1]These printed wiring boards contain model dependent components. When ordering spares or replacements, please specify the TWTA model number for compatibility. Spare boards part numbers for each model are shown in Table 1-4.

## TABLE 1-4

## SPARE PARTS

| TWTA Model Number | Regulator Board | High Voltage Board |
|---|---|---|
| 8001H11F-000 | B704194-111 | B704156-111 |
| 8001H12F-000 | B704194-112 | B704156-112 |
| 8010H09F-000 | B704194-109 | B704156-109 |
| 8010H01F-000 | B704194-101 | B704156-101 |
| 8010H13F-000 | B704194-113 | B704156-113 |
| 8010H16F-000 | B704194-116 | B704156-116 |
| 8010H02F-000 | B704194-102 | B704156-102 |
| 8010H06F-000 | B704194-106 | B704156-106 |
| 8010H07F-000 | B704194-107 | B704156-107 |
| 8010H03F-000 | B704194-103 | B704156-103 |
| 8010H04F-000 | B704194-104 | B704156-104 |
| 8010H15F-000 | B704194-115 | B704156-115 |
| 8020H09F-000 | B704194-129 | B704156-129 |
| 8020H10F-000 | B704194-120 | B704156-120 |
| 8020H01F-000 | B704194-121 | B704156-121 |
| 8020H02F-000 | B704194-122 | B704156-122 |
| 8020H03F-000 | B704194-123 | B704156-123 |
| 8020H04F-000 | B704194-124 | B704156-124 |

For 200 VAC input the regulator board dash number should be changed to the 200 series with the same last 2 digits. (Example B704194-124 becomes B704194-224.)

# 2.0 OPERATION

## 2.1 INTRODUCTION

The 8000H Amplifier is a reliable, high performance instrument designed for easy and trouble-free operation. It is important to read Sections 2.2 and 2.3, which provide general information about the amplifier, before operating the amplifier. Descriptions of the controls and indicators and operation and shutdown instructions follow in Sections 2.4 and 2.5.

## 2.2 WARNINGS

The following are general precautions to be taken in operating the 8000H Amplifier.

**WARNING**

**Lethal voltages exist in the operation of the 8000H amplifier. Remove all power connections before performing any work within the amplifier chassis.**

**WARNING**

**The traveling wave tube inside the amplifier may contain beryllium oxide ceramics. Do not attempt to disassemble the TWT. Proper disposal of damaged or worn out TWTs is required.**

## 2.3 OPERATING REQUIREMENTS AND CAPABILITIES

### 2.3.1 Amplifier System Requirements

As a laboratory instrument, the 8000H Amplifier is designed to function with a variety of systems. The broad bandwidth characteristic of the TWT utilized in the 8000H is the key parameter providing this capability. The TWT is a rugged device but requires care in several areas. Primary concerns in the setup and operation of the amplifier are preventing high VSWR at the amplifier output and avoiding overdriving the input of the amplifier.

### 2.3.2 System RF Output Power Requirements

**CAUTION**

**Use RF system components that can safely handle the output power of the amplifier.**

The amplifiers are rated at a minimum RF output of 1, 10, and 20 watts, depending on the model. They may, however, provide 3 to 4 dB of RF power output above their rating. Therefore, the components of the RF output system should have the capability of handling this power with a margin of safety.

### 2.3.3 Amplifier Load VSWR Requirements

**CAUTION**

**Never operate the amplifier into a load VSWR greater than 2.5:1.**

A mismatch greater than 2.5:1 VSWR at the RF output of the traveling wave tube (TWT) may cause permanent damage to the TWT. A TWT damaged because of such mismatching may not remain adjustable under the warranty provisions. For systems having a potentially high VSWR, Option J should be specified for TWTA self-protection.

**2.3.3.1 Match System Bandwidth to Amplifier Bandwidth** - When operating the amplifier into waveguide systems, take care that the cutoff frequency of the waveguide system does not occur within the bandwidth of the amplifier. This mid-frequency range cutoff point may be seen by the amplifier as a VSWR higher than 2.5:1, resulting in amplifier instability or even permanent damage to the amplifier.

**2.3.3.2 Avoid Amplifier RF Load Short Circuits** - Never operate the amplifier into a system open or short circuit. This may result in a VSWR higher than 2.5:1 at the amplifier output. Take care that all system connections are fully connected and snug before operating the amplifier. If it is necessary to disconnect the RF lines during operation of the amplifier, always pre-install an isolator to protect the TWT. The RF lines should only be disconnected when the unit is in standby or off condition.

**2.3.3.3 Properly Terminate TWTA RF Input** - While the RF input is not as susceptible to damage due to VSWR mismatch, good practice is to properly terminate with a load not exceeding 3:1 VSWR. The unit can be induced to oscillate if operated with the input not properly terminated, which could cause a TWT failure. Overdrive by 3 dB can damage the input circuit of the TWT.

### 2.3.4 Amplifier Output Power Capabilities

**CAUTION**

**Never drive the TWT beyond saturation. (See Figure 2-1.)**

Some amplifier models have gain up to or greater than 50 dB in areas within their bandwidth. Take care that the amplifier is not driven beyond the saturation point.

**2.3.4.1 General Procedures to Avoid Oversaturation.** - Take care to avoid oversaturation by observing the following precautions:

1. Check the frequency of operation and note the output power expected.

2. If in doubt about the gain to be expected, start with a very low level of RF drive and monitor the output power.

3. Increase drive in even steps, while observing output power.

**NOTE**

Output power should always increase with increasing input power until saturation is reached.

4. If output power begins to decrease with increased drive, immediately reduce the drive.

## 2.4 AMPLIFIER OPERATION

**CAUTION**

**Read the preceding sections before operating your amplifier.**

### 2.4.1 Controls and Indicators

Figure 1-1 shows the front and rear views of the amplifier, calling out the controls, indicators, and connectors. Table 2-1 describes the functions of the controls. Table 2-2 describes the 8000H fault indicators.

### 2.4.2 Initial Operation

**2.4.2.1 Installation** - If this is the first installation or a reinstallation after repair, refer to Paragraph 6.3 for instructions on mechanical and electrical installation and checkout.

**2.4.2.2 Primary Power Requirement** - Confirm that the primary power source is of the same type which is specified on the label on the amplifier bottom panel.

**2.4.2.3 Connecting to Primary Power** - Observe that the front panel POWER rocker switch is off (lower part of rocker switch level with panel). Connect the amplifier line cord to a primary power source which is of the same type as specified on the amplifier bottom panel label.

TABLE 2-1

8000H TWTA CONTROLS

| Nomenclature | Function |
|---|---|
| POWER | Connects prime power to all EPC circuits and initiates filament warm-up cycle for TWT. |
| OPERATE<br>STANDBY/RESET | Turns on High Voltage section of EPC and sequences TWT to active state. STANDBY/RESET de-energizes HV circuits and also resets the fault counter. |
| Remote/LCL<br>(option F on rear panel) | Transfers the two preceding control functions exclusively to a remote location. |

TABLE 2-2

8000H FAULT INDICATORS

| Nomenclature | Condition |
|---|---|
| HELIX | Helix current of the TWT has exceeded the factory set SAFE level and protective shutdown has occurred. |
| INTLK | The mechanical interlock switch has been opened. |
| TEMP | The thermostat switch located near output end of the TWT has sensed a baseplate temperature exceeding 185°F (85°C). |
| LINE | The ac prime power applied to the TWTA is insufficient to maintain the precise regulated voltages. This occurs when the ac input voltage is less than 90 percent of nominal rated voltage. |

### 2.4.3 System Setup

1. Check that the front panel POWER rocker switch is off.

2. Connect the amplifier into the system or setup with the RF source to the RF INPUT connector and a suitable RF load connected to the RF OUTPUT connector.

3. Check that the RF load is capable of dissipating the TWT output power at the intended operating frequency.

4. Check that the exhaust air flow is not blocked.

**NOTE**

On units with Type "N" coaxial RF connections, the RF output must be connected to complete the RF interlock circuit.

### 2.4.4 Power On

On the front panel, switch the POWER rocker switch on. The green ON/STANDBY display LED will light. If the LED does not light, check the fuses and the line cord. The fan should be running. A three-minute delay for the TWT heater to warm up is initiated. 8001H models will have a slightly longer warm-up delay. (ON amplifiers with option F remote, supplied +15.0 Vdc is required for turn-on in remote control mode.)

### 2.4.5 Traveling Wave Tube Amplifier On

1. Check to ensure that the RF drive source is off, or if that is not possible, at a very low level of power output.

2. On the front panel, switch the OPERATE rocker switch on. If the amplifier has completed warmup, the green OPERATE display LED will light.

3. Check to see that there is a low-level current indication on the front panel HELIX CURRENT bar graph display. No other display LED should light.

**NOTE**

1. Some TWTs have very low helix current with no RF drive. Thus, the helix current meter may not indicate until RF drive is applied.
2. Actuation of the OPERATE switch before complete warmup will not damage the TWTA. The automatic circuits will sequence to operate after latch-in of the internal timer.

### 2.4.6 Applying RF Source

1. Turn on the RF drive source at a low level.

2. Monitor the RF output by means of a directional coupler and power meter (see Paragraph 4.3).

3. Slowly increase RF drive source power until the RF output power is at its peak. This is the saturation level of the TWT (see discussion in Paragraph 2.7.1) and will vary over the operating band.

4. If possible, monitor the input power. Check the test data sheets provided for the proper drive level to ensure that the unit is not overdriven.

### 2.4.7 Routine Operation

**2.4.7.1 Removing RF Output** - During operation, broadband noise is always present in the output of the amplifier. To make adjustments or changes which are difficult or impossible in the presence of this noise, set the OPERATE/STANDBY/RESET switch to STANDBY/ RESET. The OPERATE light will go out. The TWTA is now in STANDBY mode.

If making a change that involves removing load termination, always set the TWTA to STANDBY mode.

**NOTE**

Operation of the TWTA in the STANDBY mode for periods exceeding four hours may reduce ultimate TWT life. It is recommended that the unit be completely powered down and restarted when needed.

**2.4.7.2 Helix Fault Reset** - Should the amplifier be overdriven by the RF source, the helix protect circuitry will switch the unit to the STANDBY mode. The OPERATE light will go out, and the HELIX fault light will light. Reduce the RF soure power level and switch the OPERATE/STANDBY/RESET switch to OPERATE. The TWTA will return to the OPERATE mode within 20 seconds.

### 2.4.8 Turn Off

To turn the unit off, remove the RF drive, switch the amplifier to the STANDBY mode, and switch the POWER switch to the OFF position.

### 2.4.9 Remote Operation

On standard amplifiers without the remote option, remote on and off operation can be achieved as follows:

1. Connect the amplifier as in Paragraphs 2.4.1 and 2.4.2.

2. Switch the amplifier to OPERATE and establish the RF drive and output levels as in Paragraphs 2.4.2 through 2.4.4.

3. The amplifier can now be turned on and off by switching the primary power on and off. With primary power applied through the line cord, the amplifier will automatically time through its warmup period and sequence to the OPERATE mode.

4. Should an RF overdrive condition cause the amplifier to go to RESET mode, removal and reapplication of the primary power will reset the unit. It will return to OPERATE mode following the automatic warmup sequence.

## 2.5 EMERGENCY PROCEDURE

Immediately set the POWER rocker switch to the OFF position for emergency power shut down.

## 2.6 REMOTE CONTROL (OPTION F)

The optional remote control capability can be used to monitor and control the amplifier from a remote location.

Switching between local and remote mode of operation can only be done at the amplifier rear panel. When the REMOTE switch is set to the remote, the turn-on sequence is controllable only from the remote location. Remote status is always present and is not switched.

## 2.7 TRAVELING WAVE TUBE AMPLIFIER CHARACTERISTICS

Traveling wave tube amplifier characteristics which directly affect your operation of the amplifier are described in this section. For more general information about the way TWTAs work, see Section 3.2.1.

Characteristics important to operation are: RF input versus RF output; noise performance; RF duty cycle; RF modulation and gain variations.

### 2.7.1 RF Input Versus Amplified RF Output

A plot of the amplified RF output power versus the RF input driving the amplifier is called a "compression" or "gain transfer" curve. An example of a compression curve is shown in Figure 2-1.

Note that the compression curve is linear at lower power input values, and a change in RF input drive causes an equal increase in power output. This linear region is where maximum gain is achieved. It is called the "small signal gain" region.

Beyond this region, further increases in input drive result in smaller and smaller increases in output. Finally, a point is reached where further increases in drive cause no increase in output. This is the "saturation point" of the compression curve. Note that the saturation area is rather broad and small changes in input power result in almost no change in output power.

As the RF drive is increased further, the power output will begin to decrease. This is called the "overdrive" region. Continued operation in this region may damage the TWT.

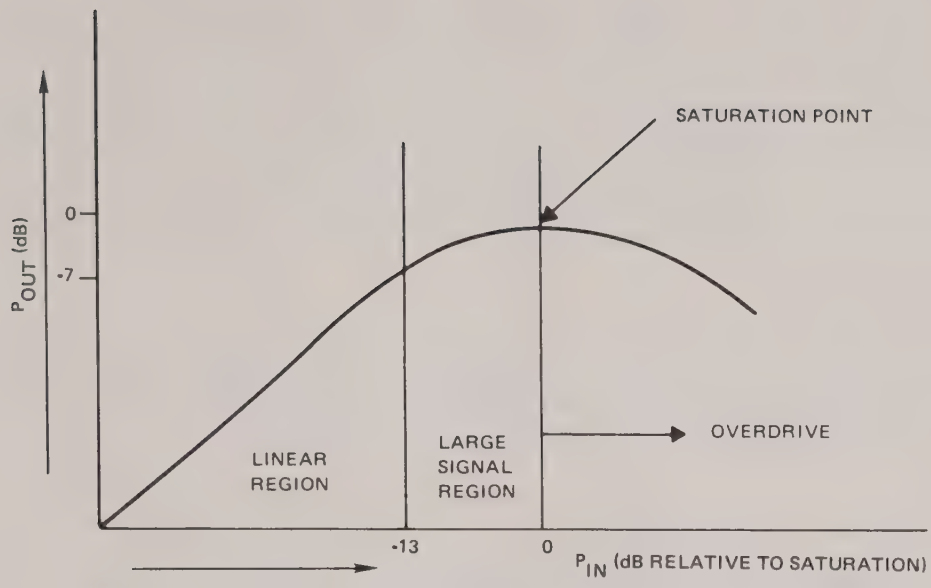



**Figure 2-1 Sample "gain transfer" or "compression curve".**

### 2.7.2 Noise Performance

Thermal noise is present at the input of the amplifier. This is increased at the output by the characteristic noise figure, bandwidth, and gain of the amplifier. In operation, the resulting noise power output of a TWT amplifier can be a high as -30 dBm/MHz.

In addition, AM and PM (or FM) noise is generated by ripple voltage on the cathode or beam power supply of the TWT and consists of combinations of modulation frequencies of the power line and converter switching frequencies. This noise is typically 50 dB below the carrier (-50 dBc).

### 2.7.3 RF Duty Cycle

TWTs utilized in the 8000H amplifiers are non-gridded and operate continuous wave. The RF duty cycle can be varied from zero to 100 percent duty by pulsing the RF drive. The maximum peak pulsed power will equal the saturated continuous wave power.

### 2.7.4 RF Modulation

With FM and PM, operate the amplifier at saturation to attain the maximum RF output at low distortion. With AM, operate the amplifier in the linear region for lowest distortion.

### 2.7.5 Intermodulation Distortion

As broadband devices, TWTAs can be used to amplify more than one carrier at a time, due to their instantaneous bandwidth characteristic.

When amplifying multiple carriers, intermodulation (IM) products will occur with levels dependent on the region of operation. Because their frequency placement comes closest to the desired carriers, third order products are of greatest concern. Figure 2-2 shows a typical third-order IM product curve. Note that in the linear gain region, a change of one dB RF output causes a 2-dB change in the third-order IM product level. In addition, note that the RF output power is distributed among the carriers and their IM products. Therefore, if the saturated output power for a single carrier is 20 watts and the TWTA is driven to saturation by two carriers, the output of each amplified carrier will be somewhat less than 10 watts due to the power absorbed by generation of the IM products.

### 2.7.6 Harmonics

The second harmonic content will be maximum when the TWTA is operated at the saturated level and is typically 8 to 12 dB below the fundamental frequency output. In some cases, where the bandwidth is an octave (that is, the upper edge of the band is twice the frequency of the lower edge) the level of the second harmonic may be higher.

### 2.7.7 AM/PM Conversion

Variations in RF input will cause low-level phase modulation on the carrier. This is called AM to PM conversion. Typically, a one-dB drive change will result in 6 degrees of phase change. Worst case occurs approximately 5 dB below the saturated drive level and is reduced at saturation or in the linear region.

### 2.7.8 Gain Variations

Because the TWTA's gain varies across its frequency range, the gain transfer curve shown in Figure 2-1 shifts accordingly. As a result it is necessary to use different drive levels to achieve maximum RF output at different frequencies.

When the amplifier is utilized with a constant drive sweeping source, adjust the drive level at the frequency of maximum gain. This procedure alleviates overdrive problems when the frequency is swept across the band. In applications where gain variations cannot be tolerated, employ other techniques. One technique is to apply a feedback signal from the RF output back to a gain control circuit at the RF source to reduce the variations in output. Another is to utilize an equalizer between the RF source and the amplifier. Equalizers are available with insertion losses which vary with respect to frequency. Utilizing the proper equalizer with the amplifier will minimize overall gain variations. Variable equalizers are obtainable.

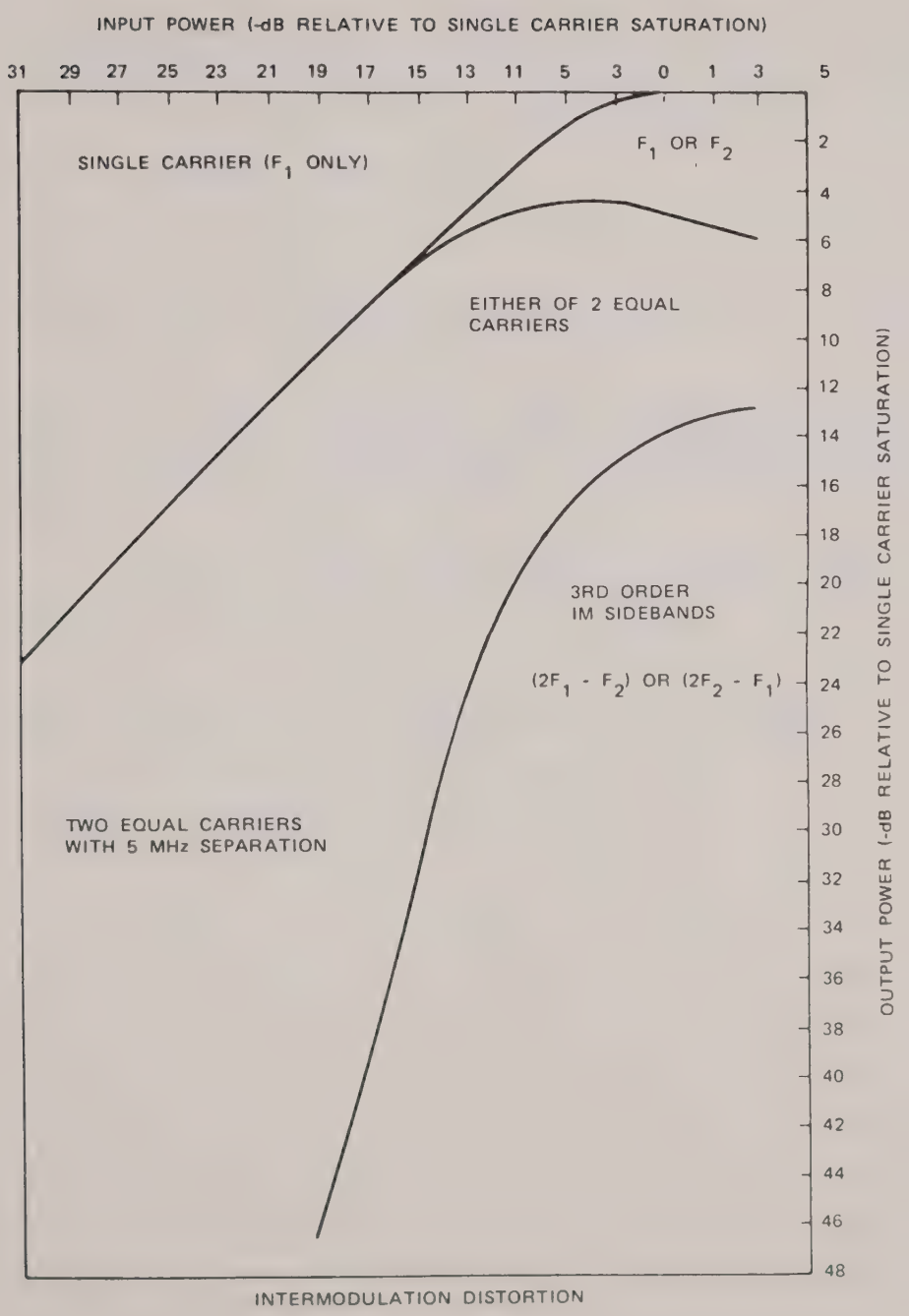

INPUT POWER (-dB RELATIVE TO SINGLE CARRIER SATURATION)
31 29 27 25 23 21 19 17 15 13 11 5 3 0 1 3 5
SINGLE CARRIER ($F_1$ ONLY)
$F_1$ OR $F_2$
EITHER OF 2 EQUAL CARRIERS
3RD ORDER IM SIDEBANDS
$(2F_1 - F_2)$ OR $(2F_2 - F_1)$
TWO EQUAL CARRIERS WITH 5 MHz SEPARATION
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48
OUTPUT POWER (-dB RELATIVE TO SINGLE CARRIER SATURATION)
INTERMODULATION DISTORTION

**Figure 2-2 Typical third-order product curve.**

## 3.0 FUNCTIONAL THEORY OF OPERATION

This section presents an overall functional description of the operation of the modules of the 8000H Instrumentation Amplifier. It is meant to provide you with an understanding of what place each module has in the performance of the amplifier. Volume II contains the analytical theory of operation which describes how the modules perform their functions.

### 3.1 AMPLIFIER FUNCTIONAL BLOCK DIAGRAM

Figure 3-1 is the functional block diagram of the amplifier. The amplifier is separated functionally into six circuits. These are:

- The logic circuits - control automatic start-up, fault display, timing, fault sensing, and the front panel inputs.
- Auxiliary regulator - supplies ± volts to the helix regulator; +15 volts to the logic circuits primary regulator, fan and the optional intermediate power amplifier (IPA); base drive to the high voltage switches; 400 V to the anode regulator; drive to the heater transformer, and synchronization to the primary regulator.
- Primary regulator - supplies primary power to the high voltage circuits, controls inrush current, isolates high voltage regulation, drive conversion, and soft start.
- Helix regulator - accurately sets and regulates the TWT cathode voltage, detects high voltage faults, and generates helix current metering.
- TWT - provides the RF ampification of the drive source.
- Remoting circuit - remotes all front panel functions.

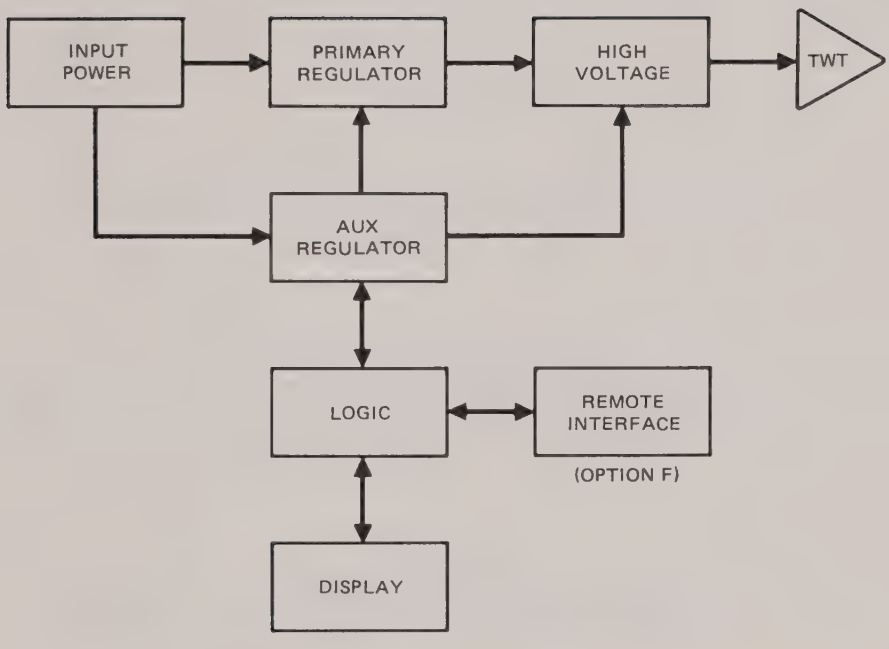



FIGURE 3-1 8000H AMPLIFIER, SYSTEM BLOCK DIAGRAM.

# 4.0 PREVENTIVE MAINTENANCE

## 4.1 INTRODUCTION

This section contains instructions for routine operator maintenance and operator replacement of common parts. If trouble does occur in the TWT or power supply, corrective maintenance should be performed immediately to prevent further damage and to restore the instrument to proper operation. See Volume II for troubleshooting and maintenance instructions.

**NOTE**

Each unit is warranted for one year. Repairs attempted during this warranty period may invalidate the warranty.

## 4.2 ROUTINE MAINTENANCE

The 8000H series amplifiers are designed for years of trouble-free operation. In the ordinary laboratory environment, no routine maintenance is required other than periodic cleaning of the air filter. However, in an extremely dusty or humid environment, such periodic maintenance procedures as visual inspection and routine cleaning, may be required.

**WARNING**

**Persons who have implanted cardiac pacemakers should completely avoid exposure to microwave radiation.**

**WARNING**

**Lethal voltages exist in the operation of the 8000H amplifier. Remove all facility power connections before opening the amplifier chassis.**

**WARNING**

**Exposure of the human body to microwave radiation of more than 1 milliwatt per square centimeter is unsafe. Operators are warned not to look directly into an open port or waveguide section while the amplifier is operating.**

### 4.2.1 Visual Inspection

Visual inspection of the amplifier at regular intervals will ensure detection of wear or damage, proper correction of which will prevent equipment malfunction or failure. Inspection should include visual checks for wear, breaks, deterioration, fungus, excess moisture, and mounting integrity. Visual inspection items are listed in Table 4-1.

**TABLE 4-1**

**VISUAL INSPECTION ITEMS**

| Potential Fault | Corrective Procedures |
|---|---|
| Connectors damaged or improperly seated in mating | Replace connector plugs, mate replacement plugs properly |
| Electrical wiring broken, burned or frayed | Repair or replace affected wires |
| Soldered connection corroded, cracked or dirty | Clean and resolder |
| Dirt or moisture causing arcing build-up, short circuits, corrosion, or overheating | Clean (See Section 6.3) |

### 4.2.2 Routine Cleaning

**WARNING**

**When using cleaning solvents, be sure to provide adequate ventilation and avoid breathing the fumes.**

The necessary materials and proper procedures for cleaning the amplifier are given in Table 4-2.

In an extremely dusty environment, it may be necessary to periodically flush the fan and heatsink with alcohol.

## TABLE 4-2
## ROUTINE CLEANING PROCEDURE

| Item | Procedure |
|---|---|
| Chassis | Clean with lint-free cloth, small vacuum or low-pressure compressed air. |
| Front panel and meters | Use a dry, clean cloth, a soft-bristle brush or a cloth saturated with isopropyl alcohol or similar cleaning fluid. Use a Kimwipe (or equivalent) tissue and GTC (or equivalent) glass cleaning compound. |
| Wire bundles and wiring | Clean with a soft-bristle brush, small vacuum or compressed air. |
| Connector jacks and plugs | Remove dust and dirt with soft-bristle brush or lint-free cloth. Remove corrosion. |
| Solder connections | Remove dirt, oil, and excess flux with isopropyl alcohol. Remove corrosion by lightly burnishing with a crocus cloth, and then clean with a lint-free cloth. |
| Waveguide assemblies, clamps, cables, and rubberized or plastic parts | Clean with a lint-free cloth moistened with a warm soap and water solution; wipe with clear water and dry. Use low-pressure air, if it is available. |
| Air filters | Remove and wash with warm, soapy water. Air dry (or use low-pressure air if it is available). |
| Power supply modules | Remove dust from perforated dust covers. Use a brush or a vacuum cleaner with a brush attachment. |

## 5.0 OPERATOR REPAIRS

Operator repair is limited to the securing or replacement of loose or missing mechanical fastenings. Note that the adjustment and replacement of major electrical components requires the services of personnel trained in the maintenance of microwave equipment. Improperly done repairs can void claims for adjustment under the warranty. (See Chapter 7, Warranty Provisions and Procedures.)

# 6.0 UNPACKING, INSPECTION, INSTALLATION, AND REPACKING

## 6.1 GENERAL

The 8000H instrumentation amplifiers are designed to operate in temperatures ranging from 0° to 50°C (32° to 122°F). Even so, to maximize instrument life, it is recommended that the equipment be maintained at or near 21°C (70°F), with a relative humidity of under 95 percent (no condensation).

## 6.2 UNCRATING AND INSPECTION

Before uncrating, inspect the outside of the packing container for any evidence of damage. If damage is evident, immediately notify Hughes Aircraft Company, Electron Dynamics Division (EDD) and contact the carrier that delivered the amplifier to submit a damage report. Failure to do so could invalidate possible claims.

### 6.2.1 Uncrating

Carefully uncrate and remove all items. Take care that all items have been removed before discarding any packing material. Save all packing material until all inspections are complete. If future repacking for shipment or storage is anticipated, save the original packing cartons.

If the shipping container or cushioning materials are damaged, keep them until the equipment has been checked for completeness and the amplifier has been checked mechanically and electrically. Verify that all items listed on the packing slips have been received. Inspect all items for evidence of damage. If damage is evident, immediately contact the carrier that delivered the equipment and file a claim. Failure to do so could invalidate future claims.

### 6.2.2 Mechanical Inspection

Check the amplifier thoroughly for damaged or loose parts. To remove the top or bottom covers of the amplifier, remove screws around perimeter of cover and slide cover off. After visual inspection is complete, reinstall cover and tighten all screws. If damage is found, file a claim with the carrier.

### 6.2.3 Electrical Inspection

Check amplifier performance against the data sheet delivered with the unit.

## 6.3 MECHANICAL INSTALLATION

The 8000H Amplifiers need only ordinary tools for mechanical installation.

### 6.3.1 Environmental Limitations

The 8000H instrumentation TWTAs are laboratory instruments designed to operate in a temperature environment of 0° to 50°C. A clearance of three inches is recommended at the rear of the instrument to ensure maximum cooling. Take care not to block the air outlet at the rear of the unit. Because the amplifier develops high voltage, a dry, dust-free installation area is best. If installed in an excessively dirty area, the unit should be periodically cleaned.

### 6.3.2 Power Requirements

**WARNING**

**Take care that the amplifier assembly is correctly grounded before power turn-on.**

For the protection of operating personnel, the National Electrical Manufacturer's Association (NEMA) recommends that the amplifier assembly panel and cabinet be grounded. The amplifier is grounded when its three-conductor power cable is plugged into a U blade receptacle. Power requirements are given in Table 1-1, on Page 2.

### 6.3.3 Rack Mounting

The amplifier configuration is designed for bench mounting or mounting in an EIA standard 19-inch rack. For rack mounting, the amplifier assembly needs no special mechanical adaption other than front panel tabs. These parts are available for field retrofit and are identified as Option E.

Proceed as follows:

1. Establish the desired front panel arrangement, allowing sufficient space for ventilation (about 3 1/2 inches) and locate the amplifier panel on the rack front risers.

2. Mount the amplifier to horizontal rails secured to the rack.

**NOTE**

Horizontal rails to support the amplifier are strongly recommended in application where the rack experiences shock or vibration.

## 6.4 REPACKING FOR SHIPMENT OR STORAGE

### 6.4.1 General

Hughes Electron Dynamics Division (HEDD) cannot be liable for damage incurred in the return shipment of any 8000H Amplifier. The following instructions are a general guide for repacking the amplifier so as to minimize such damage. Procedures to be followed in the case of return under warranty are covered in Chapter 7.0 of this manual. If there are any questions, contact the local Hughes representative or Hughes Electron Dynamics Division (HEDD) regarding the return of an amplifier or amplifier part to HEDD.

### 6.4.2 Repacking

If the original container is available, place the amplifier in the container, making sure that there is adequate packing material around all sides of the unit and that the front panel is protected with cardboard strips.

If the original shipping container and packing material are not available, refer to Figure 6-1 and proceed as follows:

1. Wrap the amplifier in heavy paper or plastic.

2. Make or select a box made of heavy wood or no less than a double-wall weight cardboard of a size that will allow at least two inches of space on all sides of the amplifier assembly.

3. Place a foam block, two-inch thick foam rubber (four- to six-pound density) in the bottom of the box.

4. Put the assembly in the center of the box and use cushioning material to completely fill the space surrounding the assembly (sides and top).

5. Close the box and tape it closed with metal bands, heavy paper tape, or fiber-reinforced plastic tape.

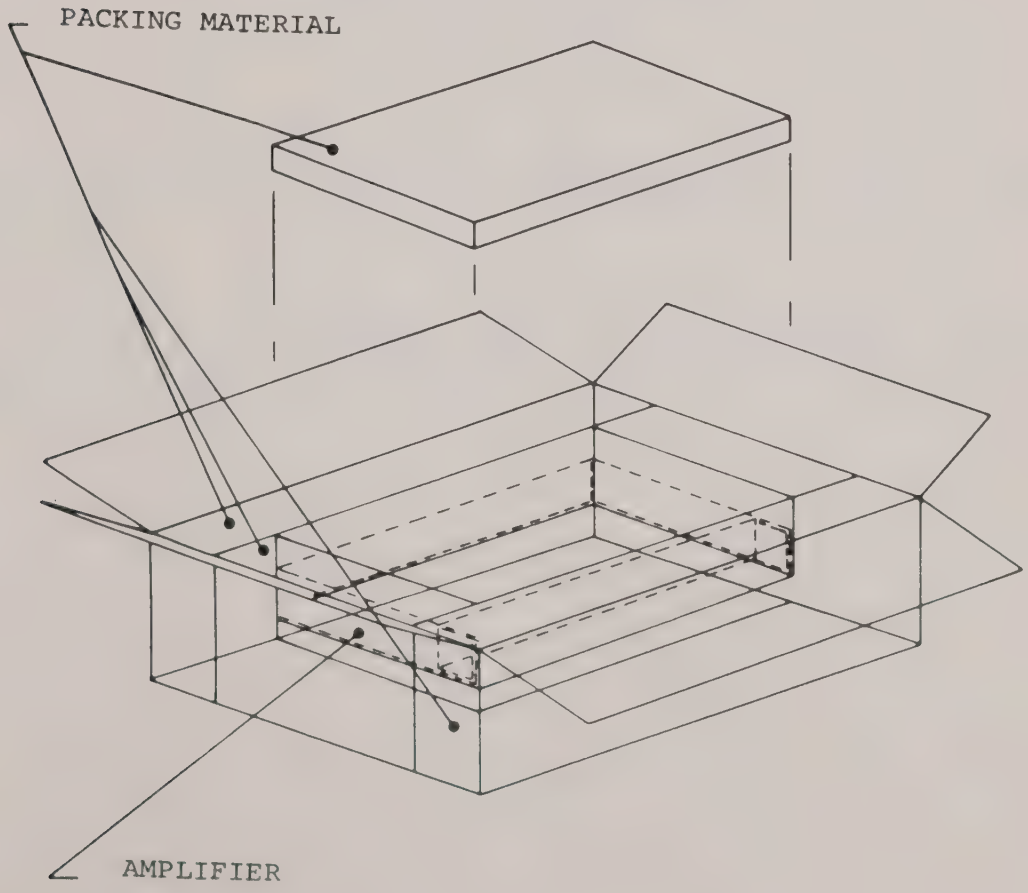



**Figure 6-1 Packing material, amplifier.**

### 6.4.3 Marking, Tagging, and Addressing

Mark the packing box "FRAGILE...DELICATE INSTRUMENT."

**NOTE**

If the amplifier is to be shipped to Hughes EDD for service or repair, attach a tag identifying service or repair wanted. A malfunction report form is contained in Section 7.0 for your convenience. The use of this form will expedite product servicing.

Refer to the transmitter by both model and serial number in any correspondence. Please use the following shipping address for all returned products.

HUGHES AIRCRAFT COMPANY
ELECTRON DYNAMICS DIVISION
3100 WEST LOMITA BOULEVARD
TORRANCE, CALIFORNIA 90509
(213) 517-6172

### 6.4.4 Shipping

Ship according to the best commercial practice. Again, for additional guidance in returning the amplifier to Hughes EDD, contact Hughes EDD or your local Hughes representative.

### 6.4.5 Storage

Do not store an 8000H Amplifier unless it has been packed as described in Paragraph 6.4.3. Store amplifier in a clean, dry indoor location with a temperature ranging from -20° to 70°C (-4° to 160°F).

# MALFUNCTION REPORT
## MICROWAVE SUB-SYSTEM

HUGHES AIRCRAFT COMPANY
ELECTRON DYNAMICS DIVISION

Please read Warranty Return Procedure before completing this form

Date Received _____

Model No. _____ Serial No. _____ Date Returned _____

1. Describe malfunction: _____

2. What are the total approximate number of operating hours: _____

3. Describe status indicators after the malfunction _____

4. Describe environmental conditions (altitude, shock, vibration, high or low ambient temperatures) other than normal handling to which the amplifier has been subjected: _____

5. Conditions prior to failure: Line Voltage _____ RF Drive _____
   RF Power Out _____ Helix Current _____

6. Conditions after failure: Line Voltage _____ RF Drive _____ RF Power Out _____

7. If unit failed catastrophically, note: _____
   (a) Indications of electrical failure _____
   (b) Indications of mechanical failure _____

8. List any system elements other than the sub-system which malfunctioned prior to or simultaneously with the unit failure: _____

9. Describe previous servicing of instrument: _____

10. Other Comments: _____

Signed _____
Position _____
Company _____
Address _____
Date _____
Phone (___) _____ Ext _____

This report must be completed and accompany all units returned to Hughes Electron Dynamics Division for action under any warranty clause.

3100 West Lomita Boulevard, Torrance, California 90509

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# WARRANTY FOR 1077H/1177H/1277H SERIES AND 8001H/8010H/8020H SERIES

## TRAVELING-WAVE TUBE AMPLIFIERS

1. Traveling-wave tube amplifiers sold by Hughes Electron Dynamics Division are warranted to the original Buyer to meet the then current published specifications, drawings and/or such modifications thereof as Buyer and Seller have agreed to in writing and to be free from defects in workmanship and materials. Seller's entire warranty obligation is limited to making adjustments by repairing, replacing or refunding the purchase price of any product which fails to meet this warranty and which is returned to Seller, as provided below, within one (1) year from date of first shipment by Seller. Replacement, repairs, or adjustments under this warranty shall not reinstate the warranty set forth herein. Under all circumstances, the warranty will expire not later than one (1) year after such first shipment. Adjustments will be made based on the period of time the unit is at Hughes EDD for repair.

2. Adjustment will not be allowed for products which have been subjected to abuse, improper application or installation, alteration, accidental or negligent damage in use, storage, transportation or handling. Alteration or removal of serial number or identification marking voids the warranty.

3. Seller shall have the right of final determination as to the following: (a) existence and cause of a defect, (b) whether adjustment will be allowed, and (c) if allowed, whether adjustment will be by repair, replacement or refund. When adjustment is not allowed, a reasonable charge will be made to Buyer to cover Seller's cost of inspection and handling.

4. In the event Seller determines that any product claimed to be defective is not subject to the warranty provisions set forth herein, Buyer will be notified that product is not subject to adjustment. Unless the Buyer furnishes disposition instructions for the product within thirty (30) days after such notification, Seller may return the product "as is" to Buyer, transportation collect.

5. In returning products under this warranty, Buyer shall comply with Warranty Return Procedure set forth on the reverse of this page. Buyer in all cases will obtain and comply with Seller's packaging and shipping instructions. Buyer will pay for packing, transportation and transit insurance costs for returned products. Credit for transportation and transit insurance charges with the United States will be issued by Seller if adjustment is allowed. Where adjustment is not allowed, products will be returned to Buyer transportation collect.

6. THERE ARE NO WARRANTIES THAT EXTEND BEYOND THE DESCRIPTION ON THE FACE OF THIS CONTRACT. Seller shall not be liable for consequential damages. No change in this warranty shall be binding upon Seller unless it shall be in writing signed by duly authorized representatives of Seller.

# WARRANTY RETURN PROCEDURE

## FOR USE BY CUSTOMER

1. Please review terms of purchase and date of shipment to determine if product is warranted and whether or not it is within warranty period and hours of operation. Adjustment cannot be made for product out of warranty.

2. If product is subject to warranty, prior to return of product, telephone, write, or wire Hughes as noted below for instructions:

**HUGHES ELECTRON DYNAMICS DIVISION**
**MARKETING DEPARTMENT**
**3100 W. LOMITA BOULEVARD**
**P.O. BOX 2999**
**TORRANCE, CALIFORNIA 90509**
**TELEPHONE: (213) 517-6162**

Product malfunctions should be reported to Marketing Department at the earliest possible time, since there are many occasions when technical assistance may eliminate the need for returning products or can prevent product damage. In the event it is deemed necessary to return the product for inspection, Marketing will provide instructions for return and, if required, a malfunction report form. All "Customer Material Returns" (CMR) require a malfunction report.

3. Malfunction reports are normally supplied with all equipments as part of the operations manuals. Additional copies are available from Hughes Marketing Department. Please give all the data requested and describe fully what occurred at the time of failure, carefully noting the operating conditions and total time the product was in use.

4. Repack the product carefully in the same manner it was orginally packaged, preferably using the original shipping carton and packaging material. Pack the completed "Malfunction Report" with the product. Ship product prepaid to Hughes by air freight in order to minimize potential in-transit damage. If adjustment is allowed, Hughes will reimburse you for air freight transportation costs within the confines of the forty-eight contiguous states.

5. Hughes will advise your company of its findings as to warranty consideration at the earliest possible time. The prompt providing of all information required above will be appreciated in order to expedite this procedure.

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